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XM982 Palladin Hold Down Strap Characterization

by Morris Berman and David Gray

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14. ABSTRACT

As the XM982 projectile transitions to its production phase, several questions were raised regarding the rounds' response to tactical vibration in the Paladin vehicle. The U.S. Army Research Laboratory carried out an extensive program to characterize the straps used to retain the projectiles in the Paladin vehicle. The characterization tests included stiffness, short-term and long-term creep. A definite relationship is shown between a strap's load carrying ability and time under stress as well as number of stress cycles.

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XM982, vibration, tactical vibration, strap, webbing

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Introduction

As the XM982 projectile transitions to its production phase, several questions were raised regarding the rounds' response to tactical vibration in the Palladin vehicle. As a result, the U.S. Army Research Laboratory began an extensive program to characterize the rounds' response to a variety of strap configurations. One part of this characterization involved understanding strap materials themselves; this report details that investigation.

Strap Material Characterization

Three tests were performed for each of the five strap materials identified in table 1. Each test utilized a new, previously untested specimen and was conducted on an Instron load frame at quasi-static rates. Five materials were tested as identified in table 1. The typical test setup for a strap in the Instron machine is shown in figure 1.

Table 1. Strap materials characterized.

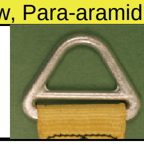
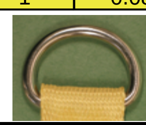
Sample	Material	End Ring	Width (inches)	Thickness (inches)
12361478-4	Yellow, Para-aramid	D-Ring	1	0.053
BWI T-10 C-7	Yellow, Para-aramid	Forged V	1.75	0.033
BWI T-10 C-8	Yellow, Para-aramid	Forged V	1.75	0.040
BWI T-6 C-9	Yellow, Para-aramid	Forged V	1	0.063
BWI T-6 C-10	Yellow, Para-aramid	Forged V	1	0.083
Forged V		D-Ring		

Figure 1. Test setup.

Stiffness Test

The objective of this test was to obtain the strap stiffness and then verify its repeatability. The straps were extended to 0.375 in. or loaded to 100 lbs (whichever occurred first) and then relaxed. This loading was repeated 20 times, resting 30 s between cycles. During the last cycle, the strap was pulled to 0.4 in.

Data from a typical test is shown in figure 2. The blue curve is the repeated load cycling of the test and shows 20 excursions from 0 pounds force to 100 pounds force with the associated hysteresis. The red lines are sequential fitting of the force-deflection curve with a linear fit. This fit is biased towards providing a better approximation of the curve at its higher force levels. The fit represents an approximate stiffness of the strap and is a linear fit of the portion of the curve between ⅓ of the peak force and the peak force for the given load cycle. The green line provides an indication of the hysteresis of each loading cycle. It indicates the deformation distance between the loading cycle's peak force and its relaxation to zero force.

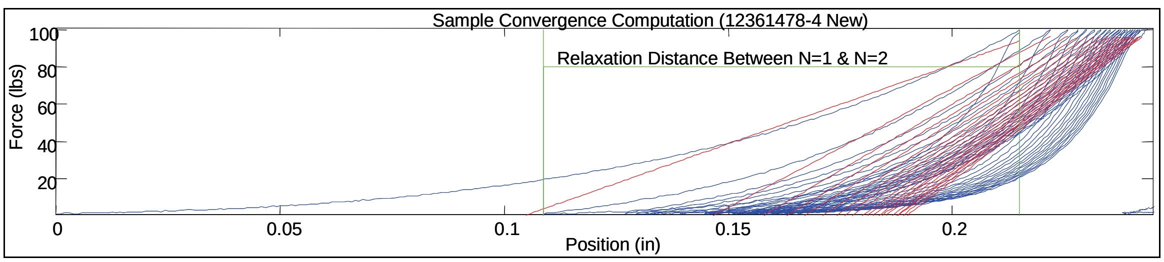


Figure 2. Typical measured data from test 1.

The plots in figure 3 summarize the data from all of the tested straps in test 1. The first plot (figure 3A) shows how the stiffness varies for each strap with each subsequent pull. The second plot (figure 3B) shows how the relaxation distance varies between load cycles. The stiffness measured in figure 3A has not been normalized for strap length, so it is applicable only to that particular strap. Both graphs clearly indicate that the response of all the straps change with repeated load application. The stiffness plot indicates that after five load applications, the stiffness change is minimal.

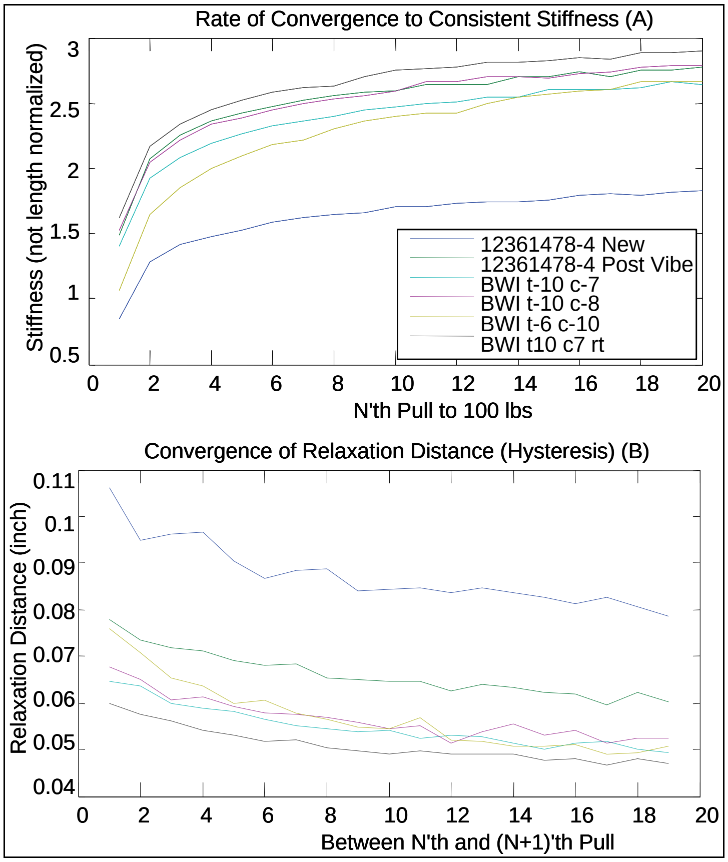


Figure 3. Test 1 summary.

Short Term Creep Test

The second test for each strap was a short term creep response. Each strap was pulled to 0.3 in. displacement in 0.05 in. increments. Between each increment, the strap was permitted to relax for 2 min. After being loaded to the full 0.3 in., the strap was then unloaded and the same loading profile was repeated.

A distance of 0.3 in. was chosen based on the measured displacements of a strap in use. As shown in figure 4, the strap was pulled tight and the first fiducial line was marked. The strap was then released and a second fiducial was marked. Measuring across the different clamps, the distance between these two fiducials ranged from 0.125 in. to 0.375 in.. A distance of 0.3 in. stretches the straps just slightly more than the service displacement but should not result in any strap damage.

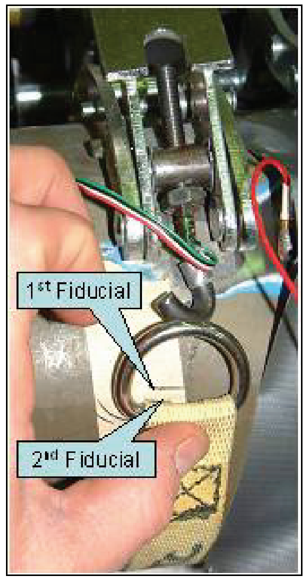


Figure 4. Displacement limits.

Figure 5 shows the data from this test series. Each plot has four curves on it. The two red curves show displacement versus force and the two blue curves show time versus force. The solid red and blue curves are the first loading cycle and the dashed red and blue curves are from the second loading cycle.

All of the straps displayed similar trends. There was some amount of relaxation of each loading increment. The relaxation force tapered off in an exponential fashion. There was a significant difference between Cycle 1 and Cycle 2 in three of five of the straps. The difference between the peak forces for both of the BWI T-6 (1 in. wide, 0.063 in. to 0.083 in. thick) straps was less than 5% whereas the same difference for the other three straps (1 in. to 1.75 in. wide, 0.033 to 0.053 in. thick) was approximately 40% to 50%. The T-6 C-9 strap manifested little difference between loading cycles for all increments of loading. The tester noted a ping or pop at approximately 1150 lbs indicating extreme fiber/seam stress for the BWI T-6 C-10 strap and a similar noise at 1300 lbs for the BWI T-10 C-7 strap.

In these tests, the second loading cycle appears to provide a stiffer response than the first loading cycle, which is consistent with the stiffness tests. An exception is the BWI T-10 C-7 strap for which the second loading cycle appears softer than the first. This could be a result of damage imparted to the strap during the first loading cycle as indicated by the noise mentioned above.

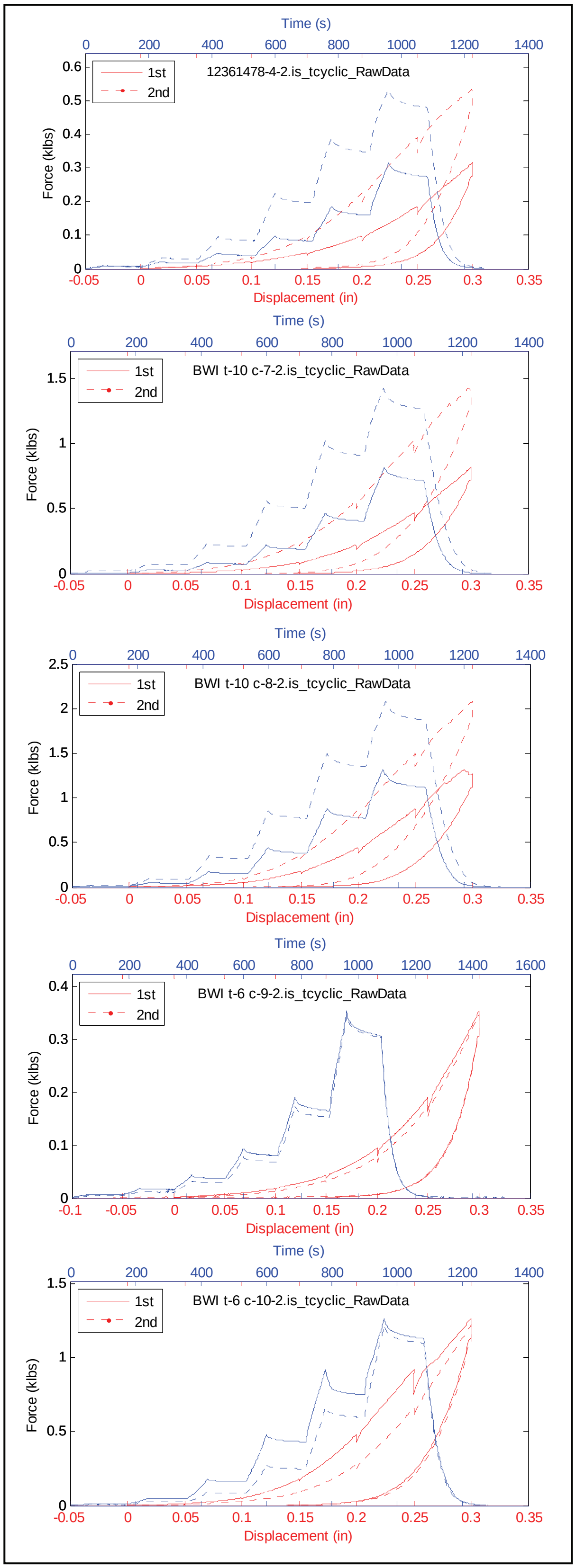


Figure 5. Short term creep test.

Long Term Creep Test

The objective of this test was to determine how each strap responds over a long duration when stressed. Each strap was stretched to 0.3 in. and held for 60 min. Then the tension was released (Cycle 1) and the strap was immediately pulled to 0.3 in. again and released without holding (Cycle 2). The data from this test series is plotted in figure 6.

The solid red and blue curves in figure 6 represent the data from the Cycle 1. The dashed red and blue curves represent the data from the Cycle 2. The blue curves show the data plotted as force versus time and the red curves show the data plotted as force versus displacement. In all cases the force reduction resulting from the creep assumes a characteristic logarithmic shape. Although relaxation occurs throughout the entire hour period, the majority occurs within the first 3 to 5 min. In all cases, the Cycle 2 does not achieve the same force at the displacement limit of 0.3 in..

The 12361478 strap appears to follow an unusual force-displacement curve on the Cycle 1 loading. It does not follow the typical exponential curve that the other straps follow. This may be due to some looseness in the strap that is taken up part way through the loading. For all the other straps, there appears to be minimal stiffening from Cycle 1 to the Cycle 2.

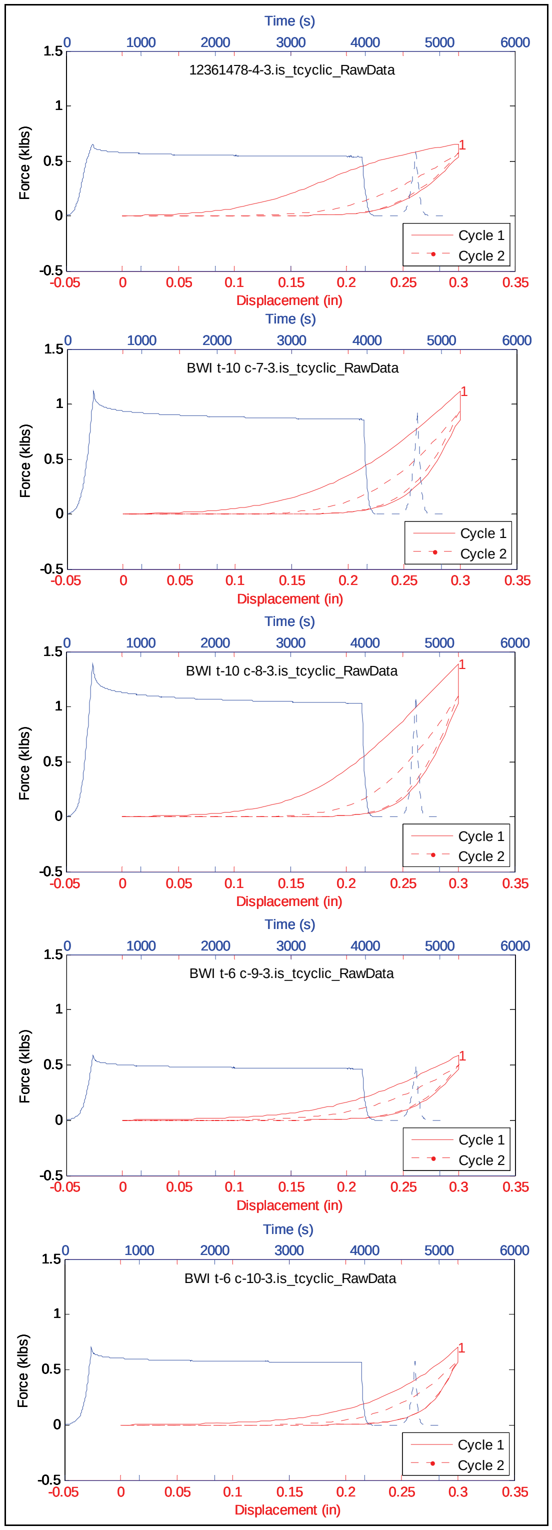


Figure 6. Long term creep test.

Summary

This series of tests was designed to provide a characterized response for a series of different straps used to restrain the XM982 projectile during tactical vibration in a Palladin vehicle. Three tests were run to characterize a different aspect of the expected response. Repeated load application tests, as well as short and long term creep tests, were executed. As expected, the force that each strap applied to the projectile varied as function of time and number of loading cycles. These tests indicate that careful attention must be paid to changing tension in the straps over the duration of a round's time in the field and that with each tightening, the turnbuckle/hook will likely need adjustment.

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